



Non-traditional Machining Processes

(Chap 9 in Textbook)

Outline

- Grinding
- Ultrasonic machining
- Chemical machining
- Electro-chemical machining
- Electrical-discharge machining
- High-energy-beam machining
- Water-jet and Abrasive jet machining

When do we need non-traditional processes

- Very high hardness and the strength of the material.
- The workpiece is difficult to clamp or flexible.
- Complexity of the workpiece shape.
- Strict surface finish requirement.
- Tight dimensional tolerances.
- Undesirable rise in temperature could damage the workpiece.

Grinding



Abrasives for Grinding

- Common abrasives

- Aluminum oxide
- Silicon carbide

- Super abrasives

- Cubic boron nitride
- Diamond

- Characteristics of abrasives

- Friability - self-sharpening
- Shape – sharp edge
- Size – grit number

Common glass	350-500	Titanium nitride	2000
Flint, quartz	800-1100	Titanium carbide	1800-3200
Zirconium oxide	1000	Silicon carbide	2100-3000
Hardened steels	700-1300	Boron carbide	2800
Tungsten carbide	1800-2400	Cubic boron nitride	4000-5000
Aluminum oxide	2000-3000	Diamond	7000-8000

TABLE 9.1 Knoop hardness range for various materials and abrasives.

Grinding Wheel

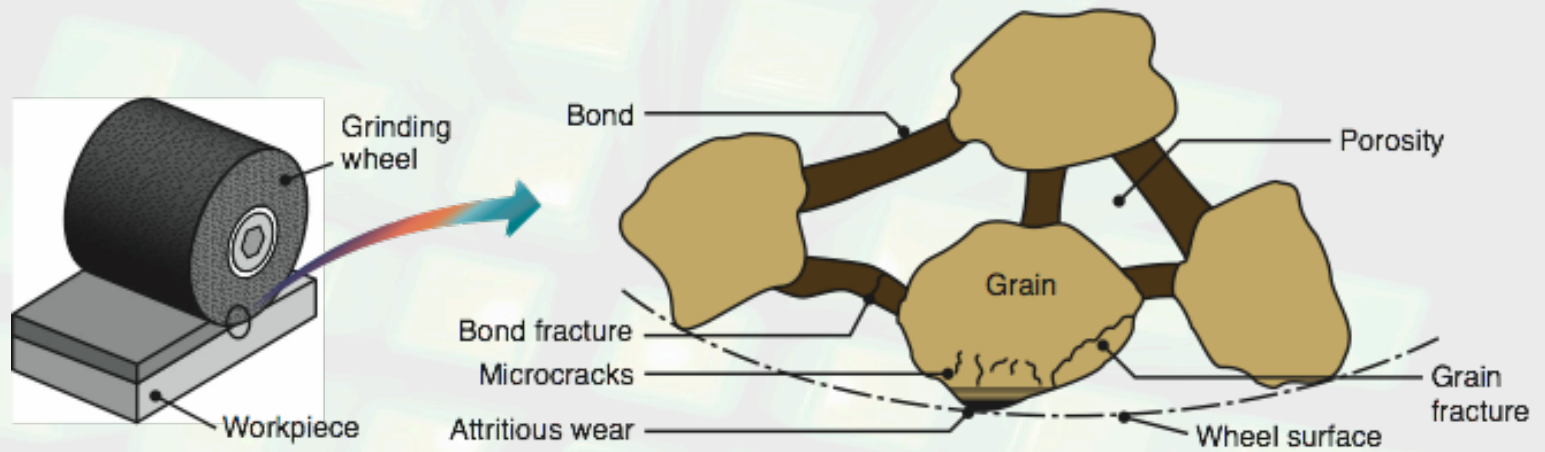


FIGURE 9.1 Schematic illustration of a physical model of a grinding wheel, showing its structure and grain wear and fracture patterns.

Abrasive Grains

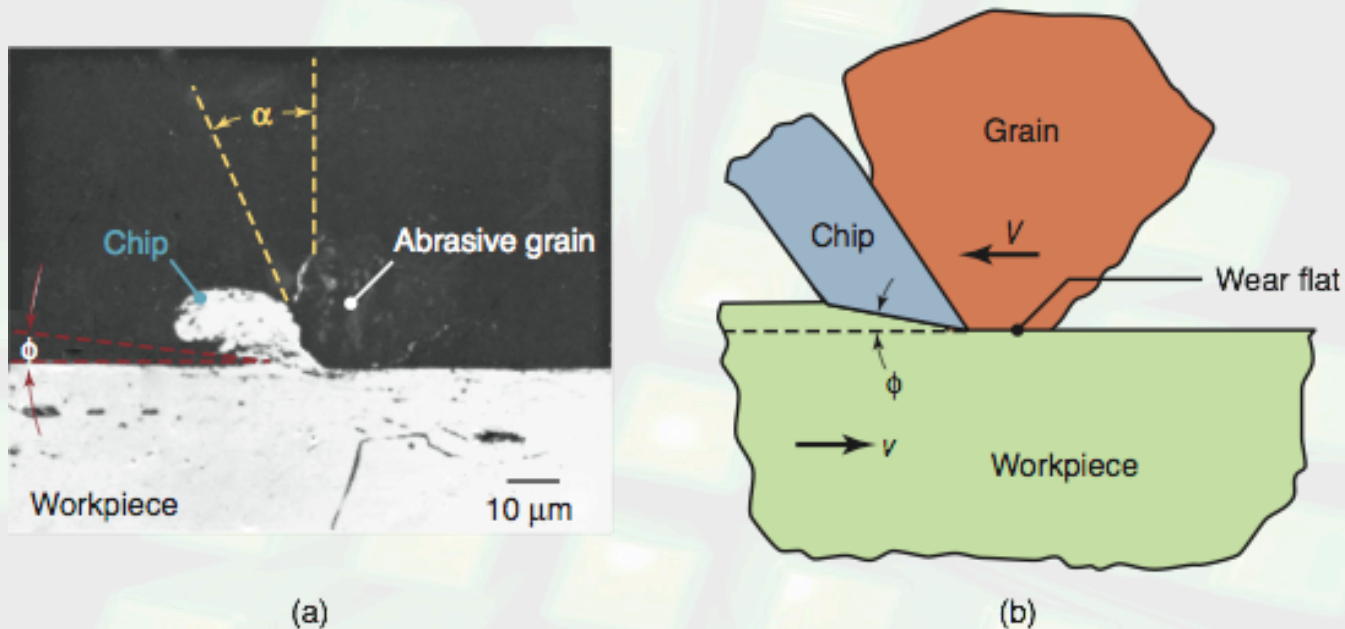


FIGURE 9.7 (a) Grinding chip being produced by a single abrasive grain. Note the large negative rake angle of the grain. *Source:* After M.E. Merchant. (b) Schematic illustration of chip formation by an abrasive grain. Note the negative rake angle, the small shear angle, and the wear flat on the grain.

Grinding Wheel Wear

- Attritious wear
- Grain fracture
 - Selection guide for grinding wheel
 - Aluminium oxide – steel, ferrous alloys and alloy steels
 - Silicon carbide – non ferrous, hard and brittle materials
 - Diamond – ceramics, hardened steels
 - Cubic boron nitride – steels and cast irons of 50 HRC or above, high temperature alloys
- Bond fracture

Grinding Fluid

A decorative background featuring a hand with fingers spread, where each finger is composed of a series of glowing, semi-transparent green and yellow cubes. The cubes have a bright yellow center and a green outer shell, creating a vibrant, futuristic aesthetic.

- **Function**

- Prevent excessive temperature rise in workpiece
- Improve part's surface finish and dimensional accuracy
- Improve grinding efficiency

Chemical-Mechanical Planerization

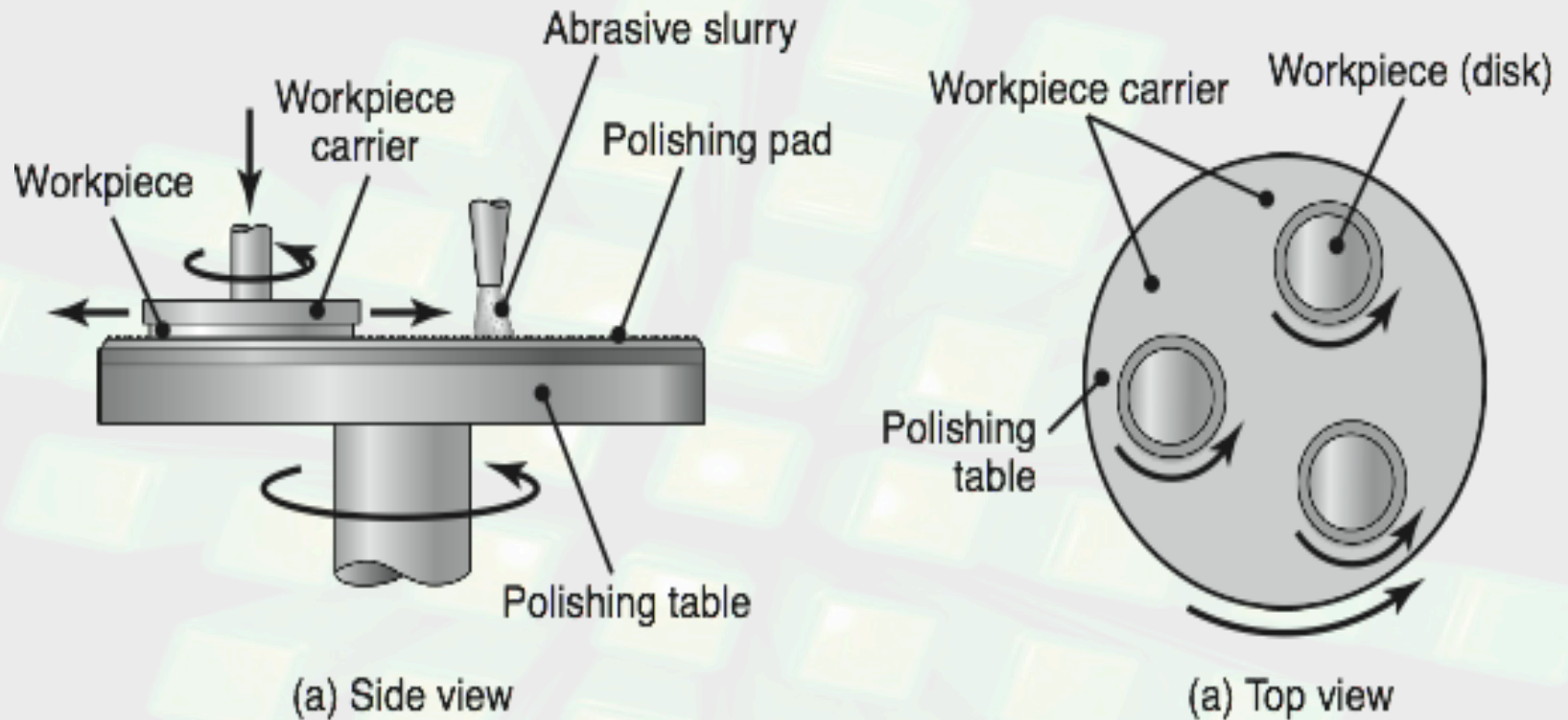


FIGURE 9.22 Schematic illustration of the chemical-mechanical polishing process. This process is widely used in the manufacture of silicon wafers and integrated circuits, where it is known as *chemical-mechanical planarization*. Additional carriers and more disks per carrier also are possible.

Ultrasonic Machining

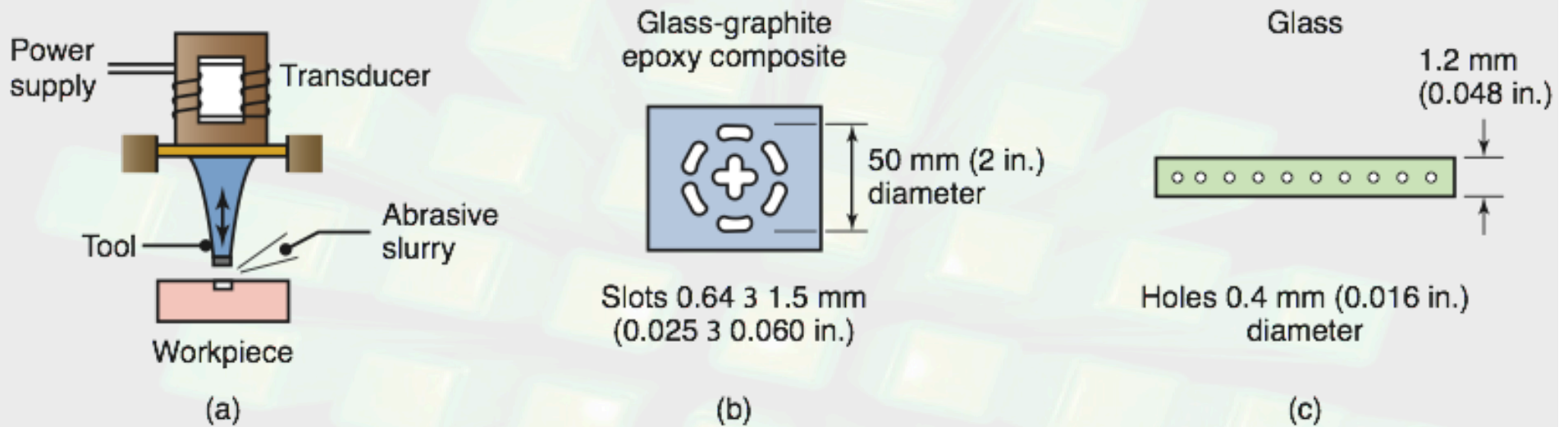


FIGURE 9.24 (a) Schematic illustration of the ultrasonic-machining process; **material is removed through microchipping and erosion with abrasive particles.**

- Typical vibration amplitude of sonotrode – 0.05-0.125 mm, freq ~ 20 kHz
- Best for hard and brittle materials – ceramics, carbides, glass, precious stones, hardened steels

Chemical Machining

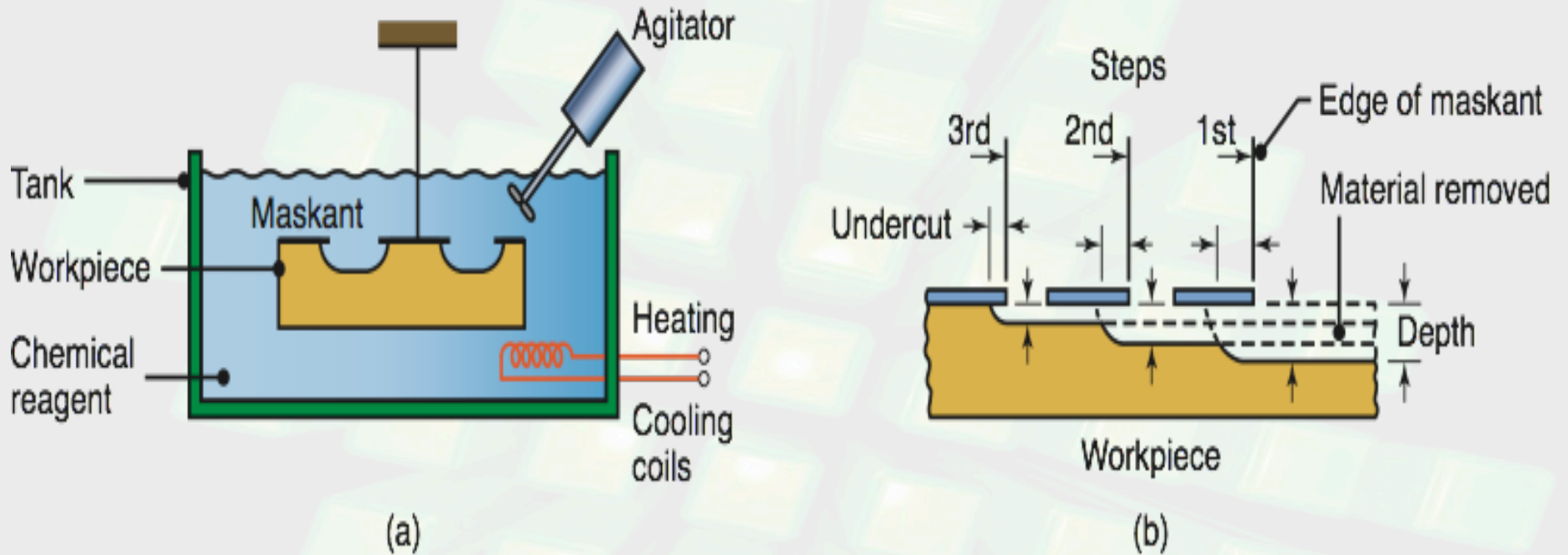


FIGURE 9.26 (a) Schematic illustration of the chemical machining process. Note that no forces are involved in this process. (b) Stages in producing a profiled cavity by chemical machining.

Chemical Milling

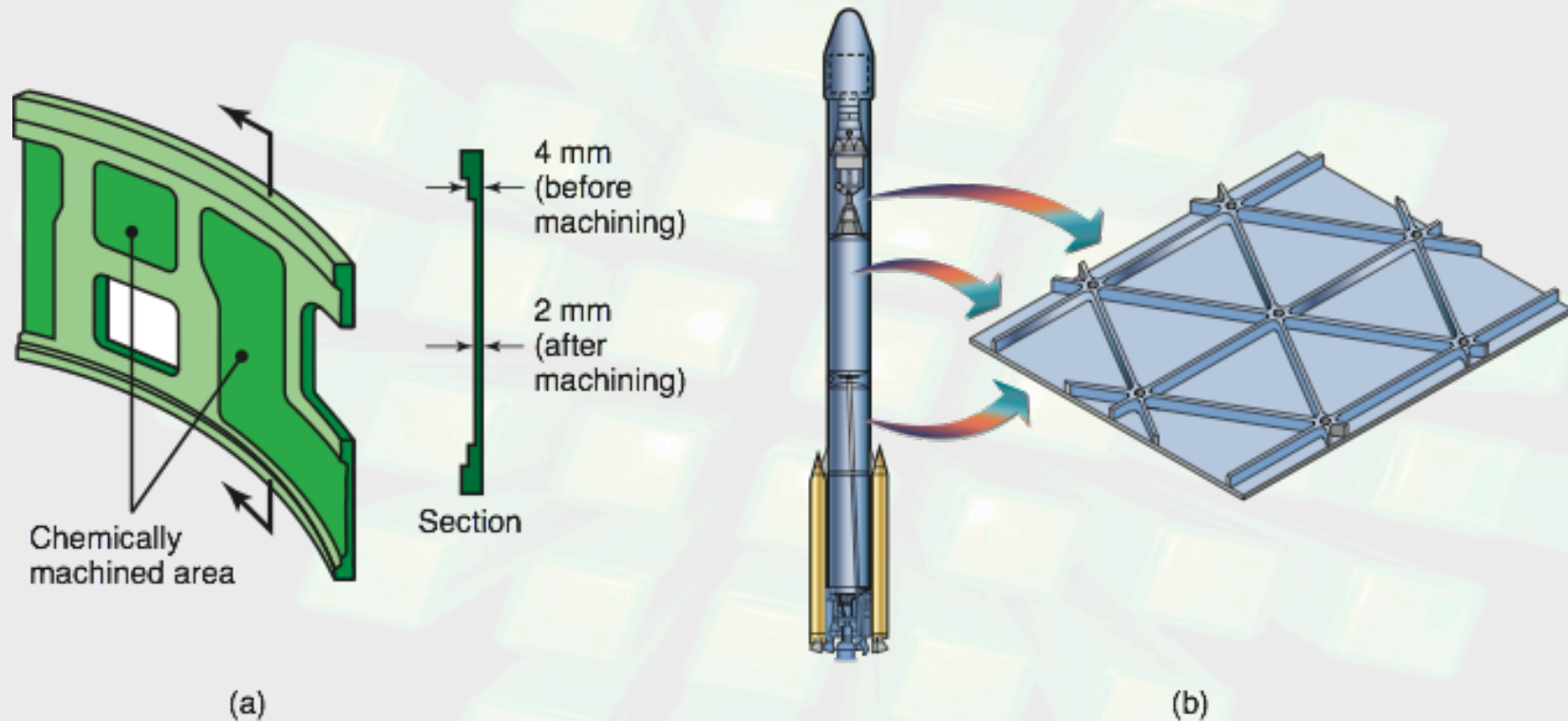
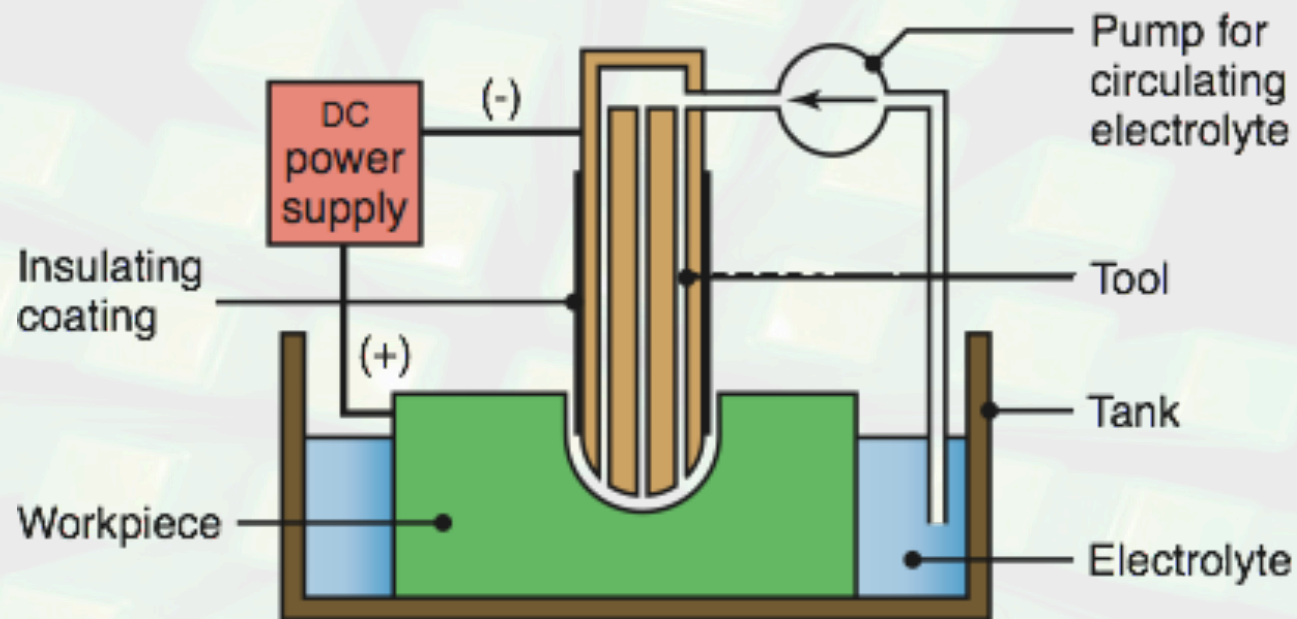


FIGURE 9.25 (a) Missile skin-panel section contoured by chemical milling to improve the stiffness-to-weight ratio of the part. (b) Weight reduction of space launch vehicles by chemical milling of aluminum-alloy plates. These panels are chemically milled after the plates have first been formed into shape, such as by roll forming or stretch forming. *Source:* ASM International.

Electrochemical Machining



- Works on the principle of electrolysis
- Die is progressively lowered into workpiece as workpiece is dissociated into ions by electrolysis
- Electrolytic fluid flows around workpiece to remove ions and maintain electrical current path

FIGURE 9.29 Schematic illustration of the electrochemical-machining process.

Electrical Discharge Machining

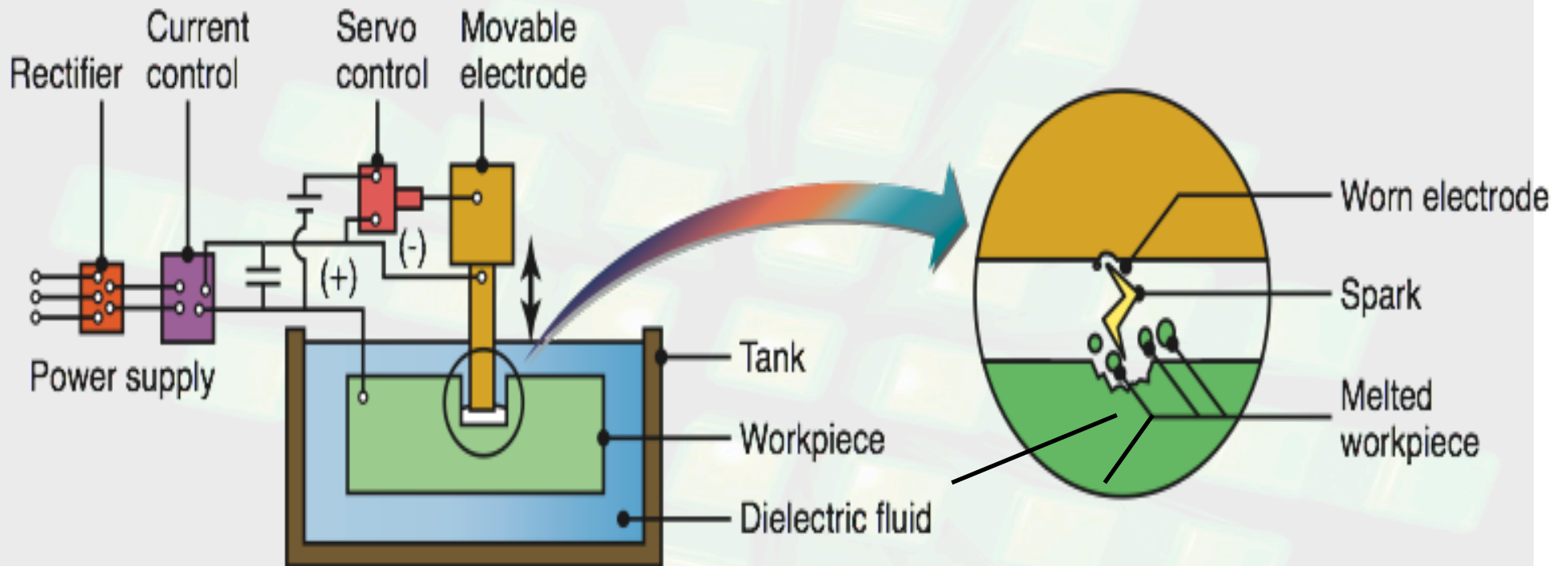


FIGURE 9.32 Schematic illustration of the electrical-discharge-machining process.

Wire EDM

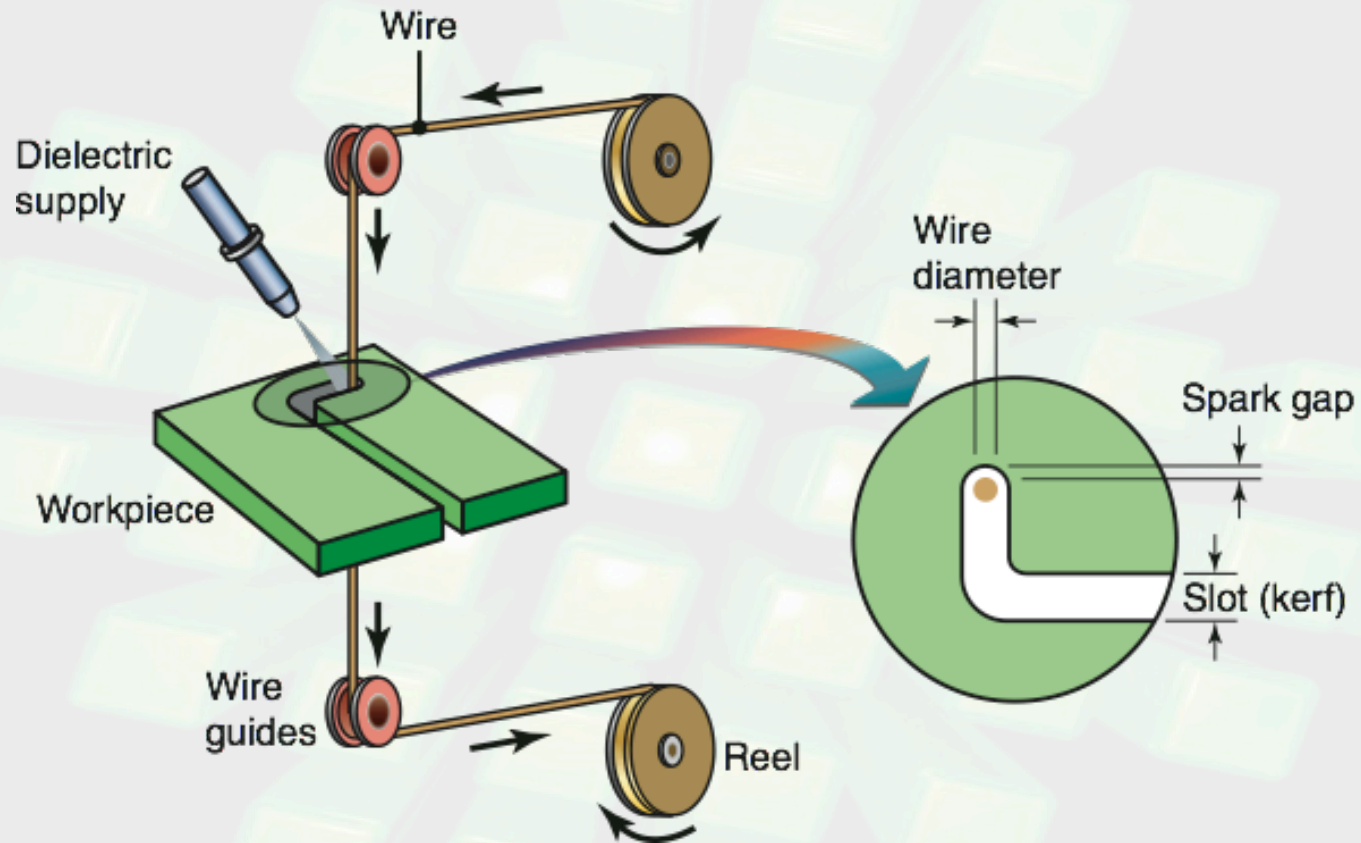
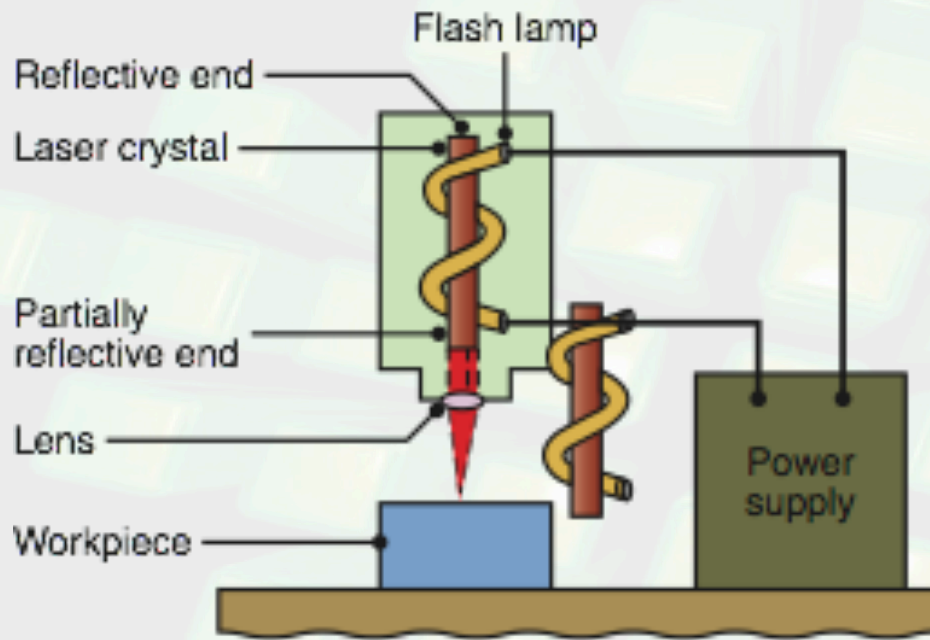
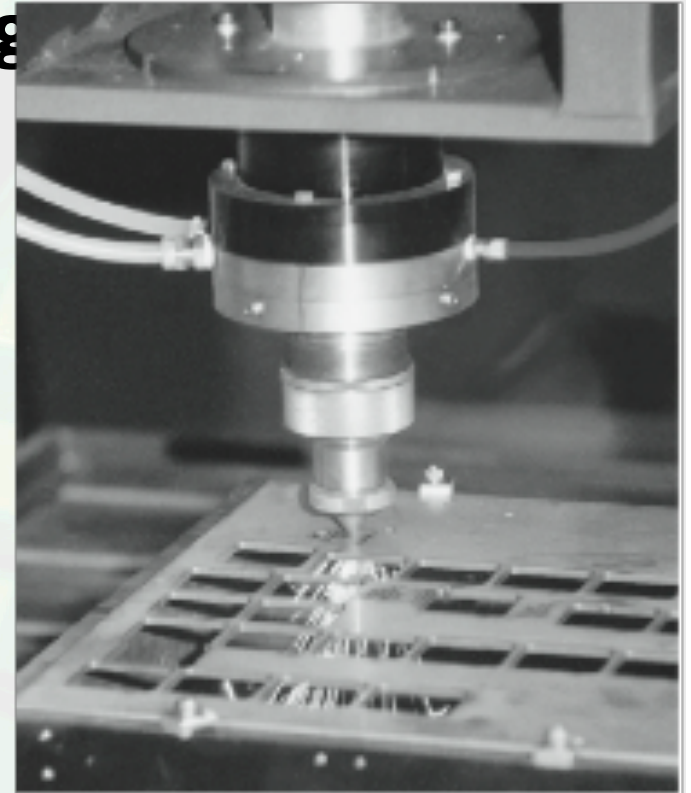


FIGURE 9.35 Schematic illustration of the wire EDM process. As much as 50 hours of machining can be performed with one reel of wire, which is then recycled.

Laser Machining



(a)



(b)

- Lasers are high intensity focused light sources
- Limited in depth of cut (focus of light)
- Would limit workpiece to less than 1 inch ($< \frac{1}{2}$ " typically)

Electron-Beam Machining

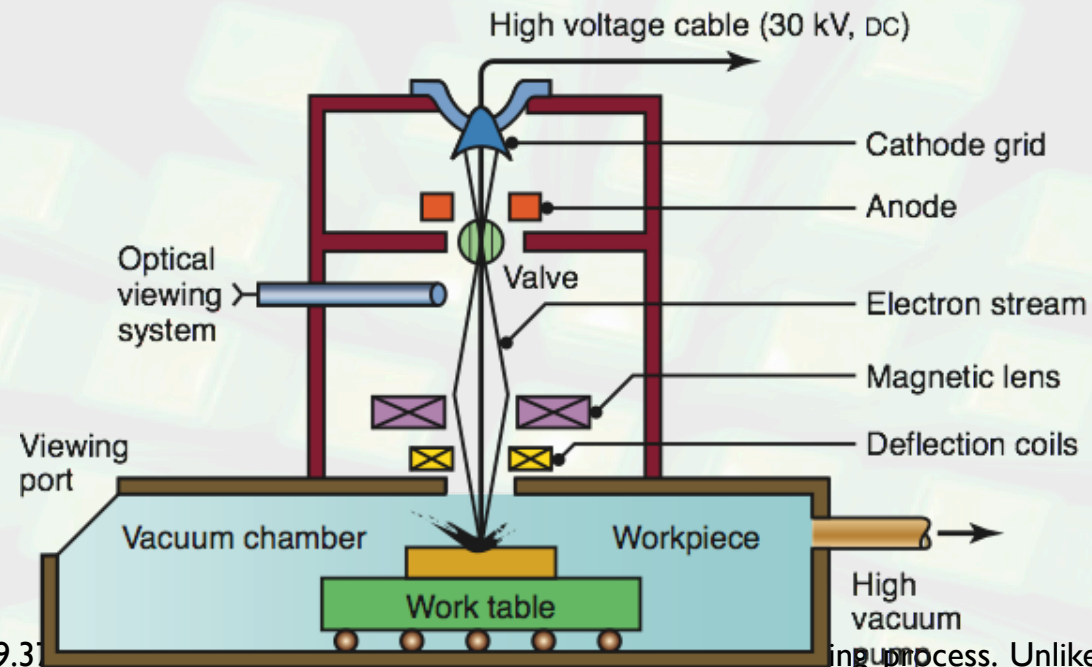


FIGURE 9.31 EBM process. Unlike LBM, this process requires a vacuum, and hence workpiece size is limited by the chamber size.

- **High velocity electrons strike the work surface to generate heat**
- **Used for accurate cutting**
- **Need vacuum chamber**
- **Interaction of electron with work piece generates X-rays**

Water-Jet Machining

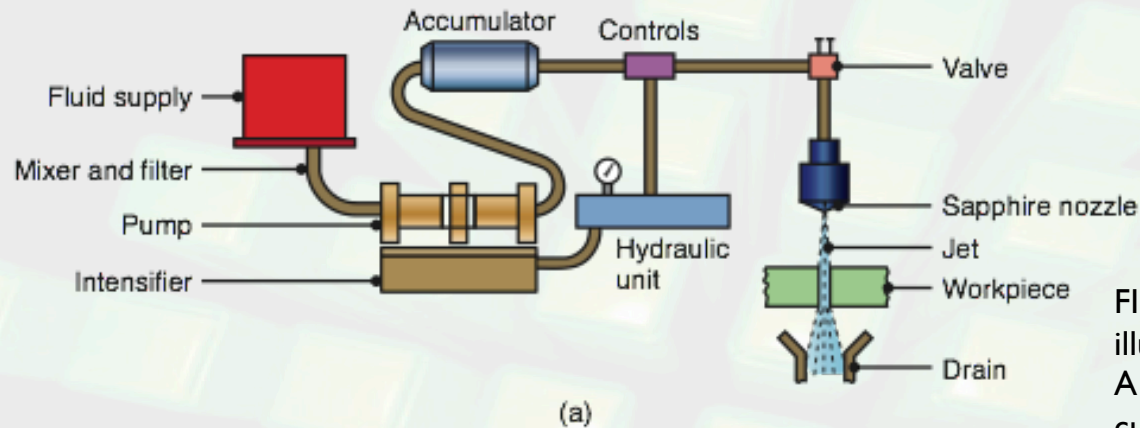
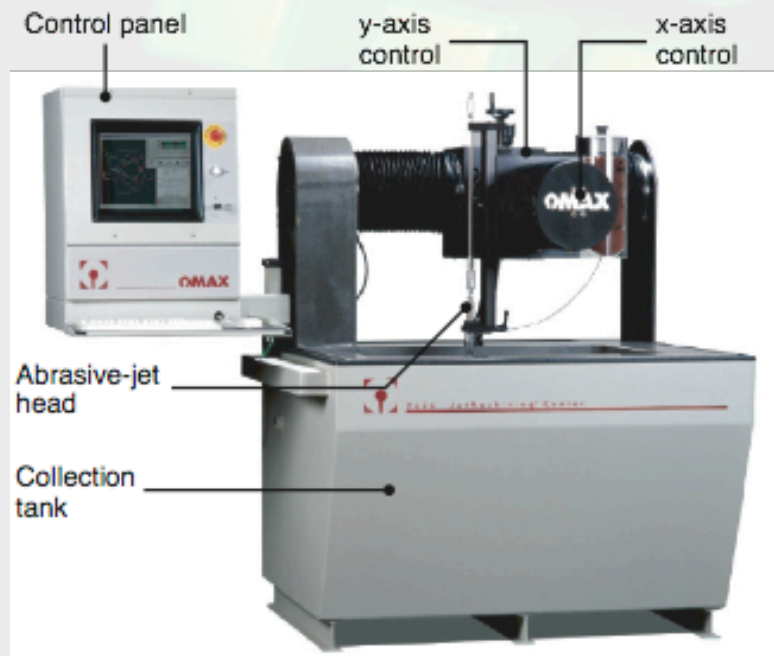


FIGURE 9.38 (a) Schematic illustration of water-jet machining. (b) A computer-controlled water-jet cutting machine. (c) Examples of various **nonmetallic** parts machined by the water-jet cutting process. Source: Courtesy of OMAX Corporation.

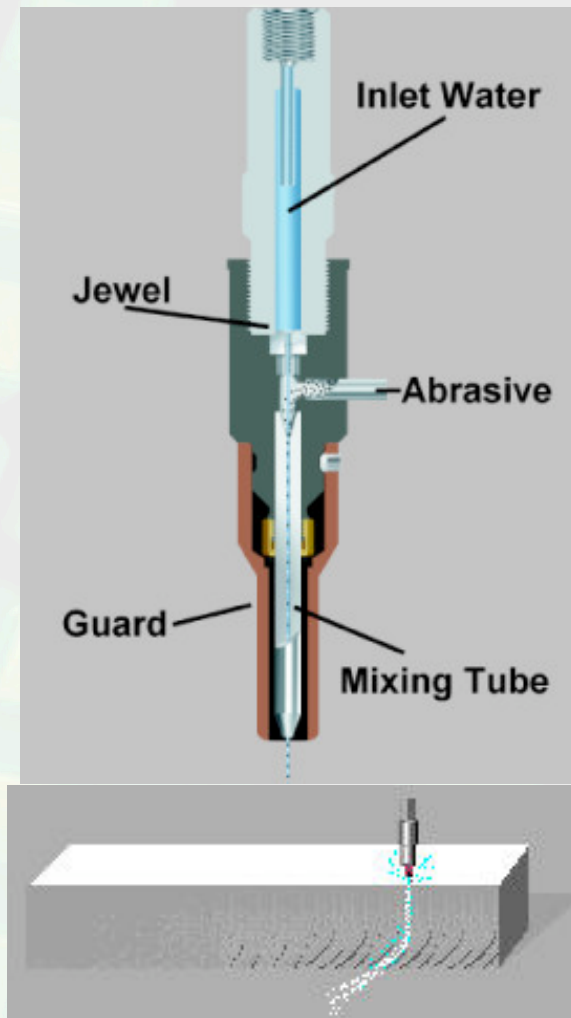


(b)

(c)

Abrasive-Jet Machining

- High pressure water (20,000-60,000 psi)
- Educt abrasive into stream
- Can cut extremely thick parts (5-10 inches possible)
 - Thickness achievable is a function of speed
 - Twice as thick will take more than twice as long
- Tight tolerances achievable
 - Current machines 0.002" (older machines much less capable ~ 0.010")
- Jet will lag machine position, so controls must plan for it



Summary

- Grinding
- Ultrasonic machining
- Chemical machining
- Electro-chemical machining
- Electrical-discharge machining
- High-energy-beam machining
- Water-jet and Abrasive jet machining

Principles, applications, process parameters